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ABSTRACT

Sixteen third grade students, 16 college students, and 16 older adults performed a lexical decision (word-nonword) task to determine age-related differences in the magnitude of contextual priming effects. Context length and target quality (intact versus degraded) were within subject manipulations. A significant Age X Context Length X Target-Quality interaction indicated changes in the magnitude of context and masking effects across the lifespan. Follow-up tests suggested that age-related differences in the magnitude of context effects could not be explained solely by age related differences in bottom-up processes (encoding), and that the efficiency of top-down processes (conscious memory search mechanisms) must also be considered. Covariate analyses, in which reaction times from simple decision tasks were used as covariates, suggested several loci for the revealed differences in context effects. (Author/MM)

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Contextual Effects Across The Lifespan*

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Abstract

Third graders, college students, and senior citizens performed a lexical-decision (word-nonword) task to determine age-related differences in the magnitude of contextual priming effects. Context length and target quality (intact vs. degraded) were within subject manipulations. A significant Age X Context Length X Target Quality interaction indicated changes in the magnitude of context and masking effects across the lifespan. Follow-up tests suggested that age-related differences in the magnitude of context effects can not be explained solely by age-related differences in bottom-up processes (i.e., encoding). The efficiency of top-down processes (e.g., conscious memory search mechanisms) must also be considered. Covariate analyses, in which reaction times from simple decision tasks were used as covariates, suggested several loci for the revealed differences in context effects.

Contextual Effects Across The Lifespan

The results from several developmental investigations have been consistent with an interactive compensatory model of word recognition (Schwantes, Boesl, & Ritz, 1980; Schwantes, 1981; Stanovich & West, 1979; West & Stanovich, 1978). According to this model, word recognition is based on the simultaneous use of information from both nonvisual (e.g., semantic, syntactic) and visual (e.g., stimulus letter) sources (Morton, 1969; Rumelhart, 1977; Stanovich, 1980). If information from one source is lacking, it is assumed that there is a greater reliance on information from sources that are readily available (Schwantes, 1981; Stanovich & West, 1981). Support for this model can be found in cross-sectional investigations in which subjects were required to perform lexical-decision (word-nonword) tasks.

The subjects made word-nonword decisions about targets that were either intact or degraded by a mask and that occurred after sentence contexts of various lengths (e.g., zero words, four words, eight words). The results indicated that young children (e.g., third-graders) made greater use of contextual sources of information than adults (Schwantes et al., 1980; Schwantes, 1981). This finding was somewhat paradoxical, because the adults were able to use preceding contexts to generate correct predictions about target words more efficiently than the children

(Schwantes et al., 1980). The apparent anomaly was explained on the basis of the interactive compensatory word-recognition model, the automaticity of encoding processes (LaBerge & Samuels, 1975; Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977), and Posner and Snyder's (1975) two-process theory of expectancy (Schwantes, 1981; Stanovich & West, 1978).

Adult subjects were assumed to process visual features of words rapidly, and automatically (Pyrd & Gholson, 1984; LaBerge & Samuels, 1975; Schwantes, 1981; Schwantes et al., 1980). Any contextual priming that occurred, therefore, was assumed to be the result of automatic-spreading memory activation mechanisms. Encoding time was not sufficient for the action of conscious-attention mechanisms (Posner & Snyder, 1975; Schwantes, 1981). In contrast, young children were assumed to process visual sources of information in a slow, effortful way. For them, encoding time was slow enough to permit the action of both automatic-spreading activation and conscious-attention mechanisms. The combined action of both mechanisms resulted in larger contextual priming scores for children, relative to those of adults.

The argument, regarding the relation between encoding time and the magnitude of context effects, gained further support from experiments in which encoding processes were slowed through target

degradation procedures (Schwantes, 1981). A significant Context X Quality X Age interaction indicated that the magnitudes of priming effects were similar across stimulus quality conditions for children, but were greater in degraded than intact conditions for adults. The increased magnitude of contextual effects for adults was explained by slowed encoding processes which allowed the combined actions of a conscious attention-spreading mechanism and an automatic-spreading activation mechanism (see also Tweedy & Lapinski, 1981; Tweedy, Lapinski, & Schvaneveldt, 1977).

Changes in the magnitude of contextual priming effects across the lifespan, then, are assumed to be determined, at least in part, by the extent to which encoding processes and memory search mechanisms are automatic. Processes that are automatic (e.g., encoding in adults), are assumed to be relatively insensitive to developmental change, while processes that require conscious attention are assumed to change with development (Brown, 1975; Hasher & Zacks, 1979; Simpson & Lorsbach, 1983). If encoding at each age level is rapid and automatic and priming is the result of automatic-activation processes, therefore, age-related differences in the magnitude of context effects are not predicted (Hasher & Zacks, 1979). If encoding speed is slowed, however, then age-related differences in the magnitude of contextual effects are expected (Hasher & Zacks, 1979, Simpson & Lorsbach, 1983). In

this case, contextual effects are assumed to be due to the combined effects of automatic-activation and conscious-attention processes. Conscious-attention processes change by becoming more efficient with development at least until early adulthood (see Brown, 1975). Therefore, larger context effects would be expected to coincide with slowed encoding processes and with more efficient conscious attention mechanisms.

The present experiment was designed to determine whether age-related differences in the magnitude of context effects (priming) can be accounted for solely by changes in encoding (bottom-up) processes, or whether the efficiency of memory search (top-down) mechanisms must also be considered. Contextual priming effects in third grade children, college students, and senior citizens were investigated as related to the quality of the target stimulus (i.e., degraded vs. intact). Based on the findings of previous investigations, and on predictions of the model discussed previously (Schwantes, 1981; West & Stanovich, 1978), the relatively slow encoding speeds of the children were expected to result in larger contextual priming effects than those found in college students. College students were expected to process words automatically and thus to produce relatively small priming effects, unless encoding processes were slowed through degradation procedures. The magnitude of the senior citizens' priming scores

was expected to reflect the nature of their encoding and memory search processes. Their encoding processes were expected to be slow, compared to the college students (Hertzog, Williams, & Walsh, 1976; Klire & Szafran, 1975; Walsh, 1976; Walsh, Till, & Williams, 1979), while their memory search mechanisms were expected to be as efficient as those of the college students, given sufficient processing time (Howard, McAndrews, & Lasaga, 1981).

The performance of the children and college students was predicted from the results of Schwantes' (1981) investigation. Schwantes (1981), however, did not report the use of simple effects tests to follow up his significant interactions (see Kirk, 1968 and Winer, 1971 for a discussion of appropriate analyses to follow-up significant interactions). As a partial replication of Schwantes' (1981) investigation, the results of this study were expected to indicate whether age-related differences in context effects remained significant when appropriate statistical tests were conducted.

Finally, the present experiment was designed to allow for statistical control of age-related changes in reaction time not associated with word-recognition processes. To our knowledge, such control has not been included in previous investigations. Therefore, whether age-related differences in reaction time

revealed on lexical-decision tasks are due to age-related differences in general encoding speed, age-related differences in encoding speed specifically associated with word-recognition, age-related differences in perceptual motor speed required for response execution, or a combination of these factors has not been determined. Reaction time data from three tasks were used to assess age-related changes in perceptual-motor and decision-making speed. The first discrimination task (asterisk-circle) was similar to a lexical-decision task in that a decision was required (i.e., "*" vs. "O") and each stimulus value had to be associated with an arbitrary response (i.e., "respond with the right hand if the stimulus is an *, respond with the left hand if it is an O"). The second discrimination task (arrow) was designed to measure reaction time when a simple decision was required and the stimulus-response associations were not arbitrary. Subjects pressed a key with their right or left hand depending on the direction of the stimulus arrow (i.e., right-pointing vs. left-pointing). A comparison of the reaction times on these two tasks was expected to reveal age-related differences in the ability to associate responses to particular stimulus values. The last (plus) task was designed to measure the time required to process and simply respond to the onset of a visual stimulus. The subjects responded as quickly as possible to the onset of a plus

sign by making a single key press response.

Method

Subjects

The subjects were 16 third-grade children drawn from a public school in a small central Oklahoma town (mean age = 8.9 years, range = 8 to 9 years; mean IQ = 106, range = 80 to 122), 16 college students recruited from Introductory Psychology classes at Oklahoma State University (mean age = 19.26 years, range = 18 to 20 years; mean IQ = 98, range = 82 to 108, mean educational level = 13.2 years, range = 12 to 14 years), and 16 senior citizens recruited from a senior citizens' center and a senior citizens' public housing facility (mean age = 69.72 years, range = 61 to 76 years, mean IQ = 105, range = 70 to 135, mean educational level = 14.78 years, range = 8 to 20 years). Analyses indicated that mean IQ did not differ among the three age groups. In addition, the mean educational level of the college students did not differ from that of the senior citizens. An equal number of males and females were included at each age level. All subjects were tested individually. The children were tested at their school, the college students were tested at the university, and the senior citizens were tested at either the senior citizens' center or at the local housing facility. The college students were given extra credit points as an inducement to participate. For each subject

who was recruited from a senior citizens' facility, five dollars was donated to that facility.

Materials

Intelligence test. Form 1 of the Quick Test (Ammons & Ammons, 1962) was used to assess intellectual functioning.

Lexical-decision task. The stimuli were 120 nine-word sentences. Of these 96 were nine-word modifications of sentences selected by Schwantes (F. M. Schwantes, personal communication, February 7, 1983, 1981) from second- and third-grade level readers. Each sentence was divided into an eight-word context and the last word of the sentence that served as the target. The sentences were selected so that 75% of the pretested children completed each sentence with the experimenter-defined target word (F. M. Schwantes, personal communication, February 7, 1983). Thirteen of the contexts provided by Schwantes were modified to fit within forty columns of the computer monitor. The remaining 24 sentences were nine-word modifications of sentences selected from second-and third-grade level readers. The target word from each of the twenty-four sentences was replaced with a nonword. All nonwords were fourth-order approximations to English (Hirata & Bryden, 1971) and were the same length as the original target, but did not begin with the same letter. Test sentences were randomly arranged in four blocks (30 trials per block), so that 24 word- and 6 nonword-target sentences appeared within each block. For a

given subject, each context and target appeared only once. As in Schwantes (1981), across subjects each target appeared equally often in each of the four stimulus quality (degraded vs. intact) by context length (zero vs. eight words) conditions.

Covariate tasks. Each of the three covariate tasks consisted of 10 practice and 20 test stimuli. The stimuli within each practice and test block of the first task consisted of an equal number of "*'s" and "O's." The stimuli for the second task consisted of an equal number of arrows pointing to the right (-→) and to the left (←-). The stimuli in the third task were all plus signs (+). Within each block, the stimuli were randomly arranged. They were all presented in the center of the computer screen.

Apparatus. An Apple II Plus microcomputer connected to an Amdek Color-I 12-inch monitor was used to present all stimulus items, record accuracy, and measure reaction times (Price, 1979; Reed, 1979). All letters were presented in capital font produced by the Apple II and were .8 cm tall and .5 cm wide. Viewing distance was approximately 30 cm. Context items were presented in the upper half of the screen, while target items were presented in the lower half. The target items were viewed through a transparent sheet of plastic (intact condition) or through plastic

on which an array of white dots (Chartpak M1536CL) had been randomly arranged (degraded condition). As in Schwantes (1981), the dot pattern reduced letter discriminability, but did not obscure the letters. Each sheet of plastic was mounted in a white paper frame (14.2 X 4.2 cm) that was attached to the computer screen.

Procedure

After intellectual assessment, all subjects performed the lexical-decision task followed by the three covariate tasks. They were seated at a table with the computer directly in front of them. The monitor was to the immediate right of the computer. Instructions for each task were presented in large letters (.5 X .2 cm) typed on standard typing paper. The experimenter read the instructions aloud while the subjects read them to themselves.

Lexical-decision task. The task consisted of four blocks of trials, 30 trials in length. Each block was preceded by three practice trials, and followed by a 2 min rest period. Half of the subjects at each age level received two blocks of trials with intact targets followed by two blocks of trials with degraded targets. The remainder of the subjects received intact and degraded target blocks in the reverse order. One of the blocks within each quality condition contained targets preceded by an eight-word context, while the other block consisted of targets

preceded by a zero-word context. The order of context lengths within blocks was balanced across subjects.

In the zero-context conditions, subjects were instructed to say "O.K." when the screen was blank to indicate that they were ready to respond. In eight-word context conditions, they were instructed to read the sentence out loud, and to use as much time as needed to read the sentence. When the subject said "O.K." or read the last word of the context, the experimenter pressed a designated key on the keyboard to initiate presentation of the target. After the key press, the screen was cleared and was blank for 1 s before the onset of the target.

Subjects were instructed to indicate whether the target item presented on the screen was a word or not a word. They were instructed to press the "/" key with their right hand if the item was a word. They were instructed to press the "Z" key with their left hand if the item was not a word. The subjects were told the items would sometimes appear clearly and sometimes they would be less clear, but that this was all part of the task. They were told to try to be correct all the time, but also to respond rapidly, and that the word "correct" or "wrong" would appear in the lower, left-hand corner of the screen to indicate the accuracy of their response. Feedback was followed by a 1 s delay before the next trial began.

Covariate tasks. Before each task, the subjects were told that they would first participate in a block of 10 practice trials. In the first covariate task, subjects were instructed to say "O.K." when the screen was blank to indicate they were ready for stimulus presentation. Half of the subjects at each age level were told to press the "/" key with their right hand if the item was an "*" and to press the "Z" key with their left hand if the item was an "O." The remaining subjects were given the opposite hand and key assignments. As in the lexical-decision task, subjects were told to try to be correct all the time, but also to respond rapidly. After the subjects indicated they were ready, the experimenter initiated a trial by pressing a designated key on the keyboard. When the subject responded, the appropriate feedback was printed in the lower left-hand corner of the screen (i.e., "correct" or "wrong"). The screen then went blank to signal initiation of the next trial.

The second covariate task was similar to the first, except that all subjects were instructed to press the "/" key with their right hand when the item was an arrow pointing to the right (-->) and to press the "Z" key with their left hand when the item was an arrow pointing to the left (<--).

In the third covariate task, the subjects were instructed to press the key they had been pressing with their dominant hand when

they saw a plus sign (+). To minimize anticipation effects, the plus sign appeared at varying intervals (.5 to 1 s) after the subject said "O.K."

Results

In order to articulate with the results of previous investigations (e.g., Schwantes et al., 1980; Schwantes, 1981), each subject's mean reaction time and proportion of correct responses were submitted to three-way mixed analyses of variance with age group (third-graders, college students, senior citizens) as a between-subject factor and context length (zero vs. eight words) and target quality (intact vs. degraded) as within-subject factors. In order to determine the loci of age-related differences in reaction time, the data were also submitted to two three-way mixed analyses of covariance.

Analyses of Variance

Reaction Time Data. A significant Age Group X Context Length X Target Quality interaction was revealed $F(2,45) = 14.47$, $p < .0001$. As may be seen in Figure 1, the magnitude of context

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Insert Figure 1 about here

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effects changed across age group and target quality conditions. Tests of simple interaction effects (Kirk, 1968, Winer, 1971)

revealed that a Context X Quality interaction was significant for senior citizens, $F(1,45) = 72.89$, $p < .01$, and approached significance for college students, $F(1,45) = 3.97$ (critical F for significance at the .05 level = 4.06). Tests of simple simple effects (Kirk, 1968) indicated that the senior citizens' reaction time was reduced by preceding context only in the degraded target conditions, $F(1,90) = 155.82$, $p < .0001$, and that degradation slowed their reaction time in both context length conditions (smallest $F(1,90) = 15.45$, $p < .001$). Pairwise t-tests indicated that the senior citizens were slowed more by degradation when the targets were not preceded by context than when they were, $t(45) = 3.67$, $p < .01$.

Simple interaction tests also revealed a significant Context X Age Group interaction in the degraded target conditions, $F(2,45) = 51.86$, $p < .01$. While tests of simple simple effects (Kirk, 1968; Winer, 1971) indicated that a preceding context reduced reaction time in the degraded target condition for all age groups, (smallest $F(1,90) = 9.90$, $p < .01$), t-test comparisons indicated that the priming scores of the senior citizens were significantly greater than those of the college students and children, who did not differ from each other (smallest $t(45) = 5.8$, $p < .01$). Priming scores for the senior citizens, college students, and children in the degraded condition were 1,336, 337, and 459 msec.

Further tests of simple simple effects indicated significant age group differences in reaction time to all degraded targets (smallest $F(2,180) = 9.87$, $p < .01$). Pair-wise comparisons indicated that, when responding to degraded targets not preceded by context, college students were significantly faster than the children and senior citizens, who did not differ from each other. When responding to degraded targets that were preceded by an eight-word context, however, the college students were significantly faster than the senior citizens, who were faster than the children.

Finally, a significant Age Group X Quality interaction was revealed at each context length (smallest $F(2,45) = 4.84$, $p < .05$). Tests of simple simple effects (Kirk, 1968) indicated that degradation slowed reaction time in all age groups at all context length conditions (smallest $F(1,90) = 5.36$, $p < .01$). T-test comparisons indicated that when targets were not preceded by context, degradation slowed the senior citizens more than the children, who were slowed more than the college students (smallest $t(45) = 2.13$, $p < .05$). When targets were preceded by context, however, degradation slowed the children significantly more than the college students, $t(45) = 2.2$, $p < .05$. Neither the children nor the college students differed from the senior citizens. As mentioned previously, the senior citizens were affected more by

degradation when targets were not preceded by context than when they were. The effects of degradation were consistent across the context length conditions for the college students and children. Finally, the age groups did not differ in their reaction time to intact targets preceded by eight word contexts. They did differ, however, in their reaction time to intact targets that were not preceded by context, $F(2,180) = 4.40$, $p < .05$. Pair-wise comparisons indicated that, for intact targets, the college students were significantly faster than the children and senior citizens, who did not differ from each other.

Accuracy Data

A significant Context X Quality interaction was revealed, $F(1,45) = 32.73$, $p < .001$. As may be seen in Figure 1, in intact conditions, percent correct ranged from 96 to 100%. In degraded conditions, percent correct ranged from 89 to 95%. The decrease in accuracy from intact to degraded conditions, corresponded to the increases in reaction time reported previously.

Analyses of Covariance

Reaction time data from the three covariate tasks were submitted to one way analyses of variance. Significant age group effects were revealed for all tasks (smallest $F(2,45) = 18.78$, $p < .0001$). On all tasks, follow-up analyses revealed that the children were significantly slower than the senior citizens who

were significantly slower than the college students. The mean reaction times for the children, senior citizens, and college students on the asterisk-circle task were 856, 515, and 424 msec. On the arrow task their mean reaction times were 892, 458, and 382 msec. Finally, their reaction times on the plus task were 650, 427, and 275 msec. Further analyses indicated that performance on the asterisk-circle task did not differ from performance on the arrow task. Performance on both discrimination tasks was significantly slower than performance on the plus task (smallest $F(2,45) = 19.10$, $p < .0001$).

Reaction time data from the covariate tasks were used to determine the loci of age-related differences on the lexical-decision task. Because performance on the asterisk-circle and arrow tasks did not differ, it was assumed that their effects as covariates would not differ. Therefore, the lexical decision reaction-time data were submitted to only two analyses of covariance. The first adjusted for the effects of performance on the asterisk-circle task, while the second adjusted for the effects of performance on the plus task.

Asterisk-circle task. Analysis of the relation between performance on the asterisk-circle and lexical-decision tasks revealed that the nature of this relation differed as a function of age group, context, and quality condition. The nature of the

age group by condition related differences are reflected in the correlational data presented in Table 1. None of the

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Insert Table 1 about here

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childrens' correlation coefficients were significant, while those of the college students and senior citizens were all significant. The analysis of covariance that was conducted adjusted for these differences (Kirk, 1968, p. 459). Unlike the analyses conducted on the unadjusted data, the analysis of covariance adjusted for the effects of performance on the asterisk-circle task revealed only significant main effects of age group, $F(2,42) = 4.97$, $p < .05$. Follow-up analyses revealed that the college students were significantly faster than the children and senior citizens, who did not differ from each other (adjusted means = 662.25, 1054.5, and 1187.25 msec, respectively).

Plus task. Analysis of the relation between performance on the plus and lexical-decision tasks revealed that the nature of this relation differed as a function of age group. The nature of the group differences are reflected in Table 1. All of the childrens' correlation coefficients were significant, none of the college students' were significant, and only one of the senior citizens' was significant. The analysis of covariance that was

conducted controlled for this difference (Kirk, 1968, p. 469). As in the analyses conducted on the unadjusted lexical-decision data, a significant Age Group X Context Length X Quality interaction was revealed, $F(2,42) = 14.47$, $p < .000$. Tests of simple interaction effects revealed that all two way interactions that were significant previously remained significant (smallest $F(2,42) = 9.87$, $p < .05$). Tests of simple simple effects revealed that the effects of context remained significant in degraded target conditions for all age groups (smallest $F(1,87) = 9.90$, $p < .01$). In addition, the effects of quality remained significant at all age group by context length conditions (smallest $F(1,84) = 5.35$, $p < .01$). Unlike the follow-up tests on the unadjusted means, the tests on adjusted means indicated that the effects of age group were no longer significant on reaction time to intact targets that were not preceded by a context ($F < 1$), or to degraded targets that were preceded by a context ($F < 1$). In fact, the only age group difference that remained significant after adjustment for performance on the plus task was the effect of age group on reaction time to degraded targets not preceded by context, $F(2,179) = 32.37$, $p < .01$. While the senior citizens were still slower than the college students, $F(1,179) = 5.79$, $p < .05$, the college students and children no longer differed in terms of their reaction time to degraded targets not preceded by context.

Discussion

The purpose of this investigation was to explore age-related differences in word recognition processes. As mentioned previously, age-related differences in the use of context have been explained in terms of age-related differences in encoding speed (Schwantes, 1981). If sufficient encoding time is available, the action of both automatic-spreading and conscious-attention memory mechanisms lead to larger context effects than if encoding time is short. Age-related differences in the efficiency of the conscious-attention mechanisms have not been considered by these theorists. We proposed, in contrast, that age-related differences in both the nature of encoding or bottom up processes and top-down processes such as conscious-attention memory mechanisms determine age related differences in the use of context (also see Goodman, 1970).

The significant Age Group X Context X Quality interaction revealed in this investigation supports previous assertions (Schwantes, 1981) that the magnitude of context effects changes across the lifespan. Previous explanations of age-related differences, however can account for only part of the data. In degraded target conditions, contextual priming effects were greater for senior citizens than for the college students. Reaction time to degraded targets not preceded by context was

longer for senior citizens than for college students. This suggests that encoding time for the senior citizens in degraded conditions was longer than that for the college students. Therefore, the larger priming effects evident for the senior citizens could be explained solely in terms of increased encoding time. The increase in encoding time allowed for the action of both automatic and conscious memory search mechanisms.

The context effects of the senior citizens were also greater than those of the children. However, the reaction time of the senior citizens to degraded targets not preceded by context did not differ from that of the children. This suggests that their encoding times in degraded conditions did not differ from each other. Thus, the time available for the action of their automatic and/or conscious memory search mechanisms did not differ. The revealed differences in the magnitude of context effects can not be attributed solely to differences in encoding time.

The differences in the magnitude of context effects between the senior citizens and children could be explained in terms of age related differences in the efficiency of conscious-attention memory mechanisms. Although encoding time for the senior citizens and children was similar, the senior citizens were able to use the context in the time available to recognize words more efficiently than the children. This interpretation is consistent with

findings that senior citizens, given sufficient time, use context (e.g., semantic cues) as efficiently as college students (Howard et al., 1981), who in turn use context more efficiently than children (Samuels & Chen, 1971, Schwantes et al., 1981).

Although the reaction time of the children and senior citizens was comparable for degraded targets not preceded by context, proponents of the encoding time view outlined previously (e.g., Schwantes, 1981; Schwantes et al., 1980) could argue that the encoding processes of the senior citizens were slower than those of the children. Thus, the greater context effects of the senior citizens could be explained on the basis of encoding speed. If encoding speed was slowed while reaction time remained the same and equivalent to the children, however, other information processes involved in the task (e.g., memory search, response selection) would have had to become faster for the senior citizens relative to the children. If memory search processes became faster, then increases in encoding time, decreases in memory search time, and possibly increases in search efficiency would correspond with increases in the magnitude of the senior citizens' context effects. Again, the argument that increases in encoding time, which simply allow for the action of certain memory mechanisims, necessarily lead to increases in the magnitude of context effects is not sufficient to explain the data. The notion

of speeded information processes in senior citizens is not consistent with findings that age associated slowing in cognitive processing is general (Salthouse & Somberg, 1982). That is, it is not associated with one type of processing such as encoding. The most parsimonious interpretation of the results of this investigation, then, is that the magnitude of context effects was determined both by encoding speed and by the efficiency with which conscious-attention memory search mechanisms worked in the time made available by the speed of encoding processes.

The data of the college students and children are also consistent with the view that the efficiency of memory search mechanisms must be considered. The data suggest that in degraded conditions the children had slower encoding processes than the college students. If increases in encoding time are necessary and sufficient for increases in the magnitude of context effects, the context effects of the children in degraded conditions should have been larger than those of the college students. The two groups did not differ, however, in the magnitude of their context effects. If the efficiency of conscious-attention mechanisms is considered, however, the lack of a difference in the magnitude of context effects can be explained. Although the slowness of the childrens' encoding processes allowed more time for the action of their conscious attention mechanisms, their mechanisms were not as

efficient as those of the college students, and thus did not result in larger context effects. This interpretation, again, is supported by findings that college students are more efficient than children in their ability to use contextual sources of information (Samuels & Chen, 1971; Schwantes et al., 1981). It appears, therefore, that increased encoding time is necessary, but not sufficient for increases in the magnitude of context effects.

When interpreting the reaction time data for intact targets, it is important to note that none of the context effects were significant. This is in contrast to the significant effects reported by Schwantes (1981). As mentioned previously, Schwantes did not report the use of simple effects tests to follow up significant interactions as suggested by Winer (1971) and Kirk (1968). The differences between the current results and those of Schwantes, then, could be the result of the use of different statistical tests. A reanalysis of Schwantes (1981) data, using appropriate statistical follow-up tests, would indicate whether the context effects remain significant for intact targets.

The question of interest in this investigation, is whether the obtained pattern of results is consistent with previous interpretations and/or can be accounted for by the current interpretation. The children and senior citizens both had reaction times to intact targets not preceded by context that were

longer than those of the college students. This suggests that their encoding processes for intact targets, like those for degraded targets, were slower than those of the college students. Based on previous interpretations, one would expect larger context effects for the senior citizens and children than for the college students. The results indicate, however, that none of the age groups differed in the magnitude of context effects to intact targets. Advocates of the encoding-time approach and the current approach would both have to explain these data in a similar way. Both may propose that although the encoding times of the children and senior citizens were longer than those of the college students, sufficient encoding time was not available for either the activation of their conscious-attention mechanisms, or for the effects of their conscious-attention mechansims, if activated, to be added to automatic effects. This interpretation is consistent with findings that senior citizens experience a general slowing of all cognitive processes (Salthouse & Somberg, 1982). That is, it may take senior citizens longer to activate conscious-attention mechanisms, or it may take longer for their mechanisms to have an effect once activated.

The absence of age-related differences in the magnitude of context effects between the children and college students suggests that, in situations similar to those in the intact conditions of

this experiment, children do not make greater use of contextual information than college students. Similarly, in intact conditions, senior citizens do not make greater use of the context than college students or children. As mentioned previously, the target words in the sentences used were highly predictable (Fishler & Bloom, 1979). It is possible that age-related effects would be revealed if the words were less predictable and recognition required the action of conscious-attention mechanisms (Samuels, Begy, & Chen, 1971).

Before discussing the data from the covariate tasks, it is important to note that analyses of the lexical-decision data did not indicate that speed-accuracy trade offs occurred in this experiment. The highest accuracy rates obtained in the intact target conditions also corresponded to the shortest reaction times.

The analysis of covariance that adjusted for the effects of performance on the asterisk-circle task revealed only main effects of age. That is, even when adjusted for age-related differences in performance on a simple decision-making task, the college students made lexical decisions more quickly than the senior citizens and children, who did not differ from each other. The data suggest, therefore, that there are age-related differences specifically related to processes involved in word recognition.

None of the significant interactions or within age group effects (i.e., context length, quality) remained significant in the asterisk-circle analysis of covariance. The results of the covariate analysis and the nature of the lexical decision-asterisk circle correlations suggest that the analysis of covariance reduced condition-related differences in lexical-decision performance between subjects within age groups. Thus, even though the analysis reduced between age-group variability due to age-related differences in encoding speed, it also reduced within group variability. This resulted in the retention of significant between group differences.

The analysis of covariance that adjusted for the effects of performance on the plus task, which was assumed to be a measure of simple encoding and response execution processes, continued to yield all significant interaction effects and only one significant age effect. In degraded-target, zero context conditions, college students were faster than the senior citizens who were faster than the children. Statistically, this analysis appeared to reduce between age-group variability without also reducing within age-group variability. This evidence is consistent with previous assertions (Schwantes et al., 1980) that age-related difrerences in encoding speed revealed on the lexical-decision tasks were due to slowed general perceptual processes in the children and senior

citizens, and were not due to perceptual processes unique to word recognition.

The results of the two analyses of covariance interpreted together suggest, then, that differences in lexical-decision performance are not large enough to remain significant if the data are adjusted only for differences in encoding speed between age groups. That is, they are not also adjusted for condition related differences in decision-making speed between subjects within age-groups. The one condition that continued to yield age-related differences when only age-related differences in encoding speed were taken into account, degraded targets alone, is the one expected to be most influenced by bottom up (encoding) processes.

In conclusion, the results of this investigation support previous assertions that sufficient processing time is necessary before contextual processes produce significant reductions in the speed of word recognition. In this investigation, encoding time for intact targets was not sufficient in any of the age groups, to produce significant context effects. Encoding time for degraded targets, however, was sufficient. Longer encoding time, produced in degraded conditions for all age groups, appeared to allow the action of both automatic-spreading and conscious-attention mechanisms. The results indicate further, that age-related differences in the efficiency and possibly the speed of top-down

processes, specifically conscious-attention memory mechanisms lead to differences in the magnitude of context effects. Such differences in top down processes should be considered when predicting age-related differences in the magnitude of context effects on lexical-decision tasks. Finally, the results of the covariate analyses suggest that both age-related differences in processes unique to word recognition and age-related differences in general perceptual processes lead to age-related differences in performance on lexical-decision tasks.

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Table 1

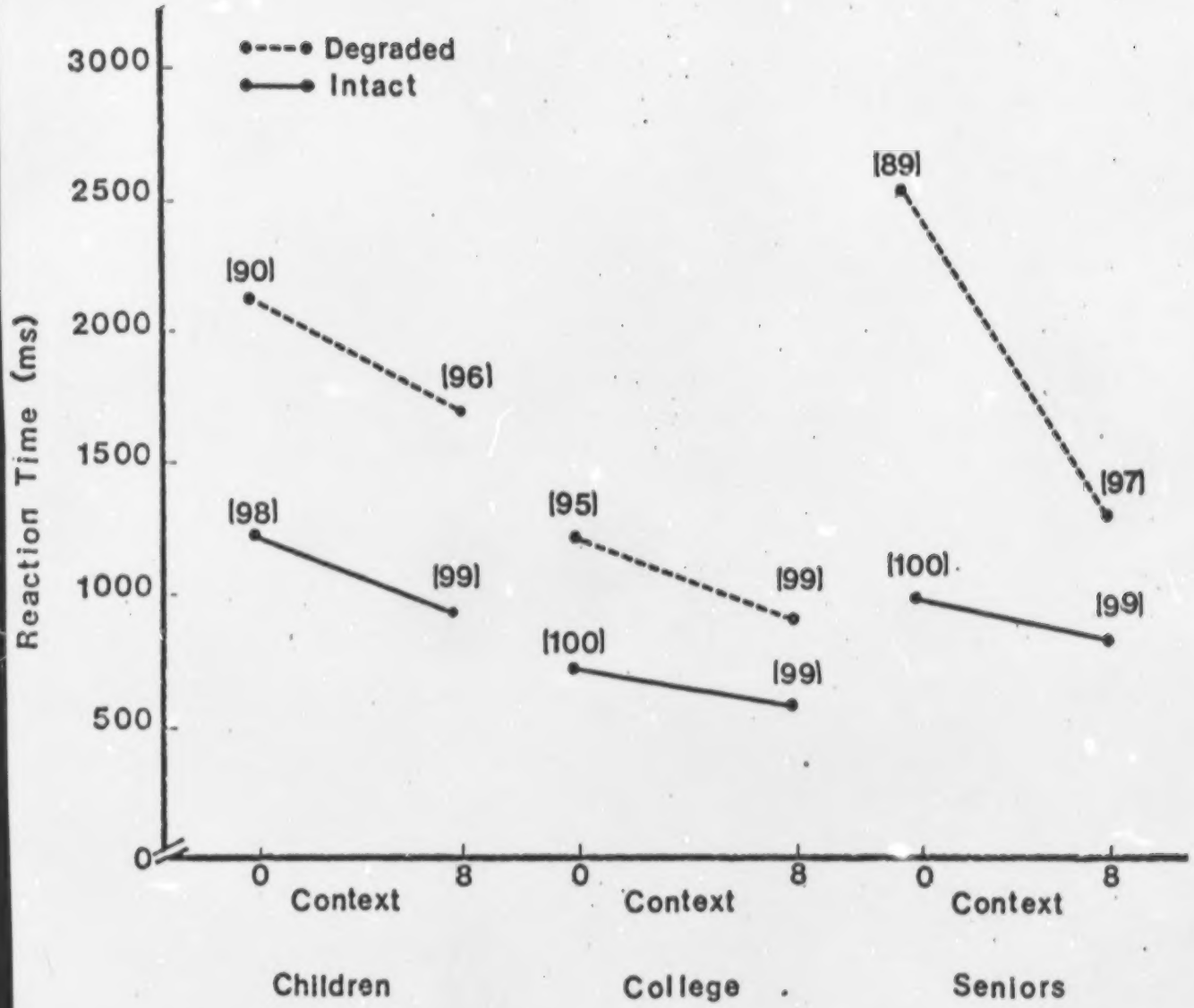
Lexical-Decision and Covariate Task Correlations

Group	Condition: Intact, 0 Word	Intact, 8 Word	Degraded, 0 Word	Degraded, 8 Word
	Asterisk-Circle Task			
Children	.25	.22	.09	.05
College	.49***	.47***	.61***	.44***
Seniors	.72***	.37***	.53***	.65***
All	.57***	.50***	.31***	.57***
	Plus Task			
Children	.31*	.35**	.35**	.41**
College	-.09	.05	-.08	-.17
Seniors	.22	.31*	.05	-.11
All	.49	.56*	.32*	.44*

*p .05. **p .01. ***p .001.

Figure Caption

Figure 1. Age Group X Context Length X Target Quality interaction effect on reaction time in the lexical-decision task. Percent correct for each condition is indicated in parentheses.


Degraded
Intact
Reaction Time (ms)
3000
2500
2000
1500
1000
500
0
[90]
[96]
[98]
[99]
[95]
[99]
[100]
[99]
[89]
[97]
[100]
[99]
0
8
Context
Children
College
Seniors
Age